CURRENT LITERATURE.

BOOK REVIEWS.

Perception and propagation of stimuli in roots.

A NEW FIELD of research in plant tropisms has recently been opened by Němec in two important papers dealing with the normal and pathological cytology of the cells of sensitive and curving regions of roots and stems. In the first of these[1] the author shows that there exist starch grains in the cells of the root caps of many roots, and in several other sensitive regions. These grains invariably occupy the physically lower side of the cells in which the lie. Most of the experiments were conducted upon the roots of seedlings and upon the coleoptiles of grasses. At the close of an experiment the organs were killed, and studied by staining and sectioning. The movement of the grains occupies a comparatively short time, a half hour being sufficient for their rearrangement in the cells of the root cap in Pisum, when this has been turned on one side. The grains are embedded in the plasma, and as they fall away from that part of the protoplasm against which they normally lie (*i. e.*, when the organ is upright), the protoplasm on that side of the cell becomes altered so that it stains much more deeply. If the organ has been so placed that when the grains come to rest they still lie against a part of the normally lower wall, only that part of the protoplasm which has been freed from them becomes altered. Cells which have been in an upright position, but have lost their starch, owing to the influence of a plaster jacket, show the same proptoplasmic thickening as those which have been turned so that the grains fall by gravitation away from their normal position. Roots so treated are found to have lost their power of geotropic curvature. The author suggests that this may be due to the loss of the starch. Also, when these roots are freed from the plaster and allowed to renew their growth, they regain their normal sensitiveness. The return of sensitiveness is accompanied by the formation of new starch grains in the root cap. Also, if the region containing the grains be cut away, geotropic reaction ceases for a time, and its return is simultaneous with the formation of new grains in the regenerated tissue.

Němec is of the opinion that the stimulus for geotropic curvature is the change of pressure of the starch grains upon the protoplasm. These variations in pressure are of such small magnitude, however, that it is well-nigh

[1] NĚMEC, B.: Ueber die Wahrnehmung des Schwerkraftreizes bei den Pflanzen. Jahrb. f. wiss. Bot. **36**: 80–178. 1901.

inconceivable that they should produce an effect great enough to be propagated through many cells and produce a reaction. It seems much more probable to us that the sensitiveness is due rather to a chemical than to a physical change of condition within the cells. This seems the more probable on account of the fact that when the grains leave their normal position, the protoplasm here becomes changed. Possibly this may be due to the removal, not of the grain, but of the leucoplast in connection with it. The chemical effect of the leucoplast upon sugars passing through it is very great (since it produces in them condensation to form starch), and it may well be that it also has an effect upon the surrounding protoplasm. There may be other, as yet invisible, substances within the cell, which cannot diffuse readily, whose specific gravity differs from that of the protoplasm, and these might affect the protoplasm unsymmetrically, thus setting up a stimulus which could be propagated to the curving region.

The second paper[2] treats of the conduction of the stimulus from the sensitive regions to the region of the curvature. Traumatropic responses in roots were chosen as field for experimentation. If the tip of an Allium root is wounded by a cut or needle thrust, the protoplasm of the meristematic cells bordering upon the wound heaps up and becomes more dense on the side toward the wound. The nucleus also migrates toward the wound, often coming to lie against the wall on that side of the cell. After a very short time these cells regain their normal condition. But in the meantime a second and third layer of cells, at the side of and behind the wound, have responded in the same manner. Thus in roots killed 15 minutes after wounding, the response has been propagated through 1.25^{mm} of tissue, but those cells within 1^{mm} of the wound have already regained their original condition. This propagation takes place most rapidly in a longitudinal direction, but only towards the base of the root. It also occurs in both directions laterally.

A careful investigation was made to determine whether this difference in the rate of propagation of the response might correspond to any difference in structure. In the cells taking part in the traumatropic reaction, longitudinal strands of protoplasm can, by proper staining, be made visible with comparatively low magnification. Sometimes there is a single strand, sometimes several; sometimes they lie near the middle of the cell, and sometimes, especially in vacuolated cells, along the lateral walls. The strands are always in contact with the nucleus, often dividing and enclosing this body between several branches which reunite beyond it. A differential stain for the branches has not been discovered, but they take the ordinary stains much more deeply than the surrounding protoplasm. The best results were obtained by staining strongly with fuchsin S.

[2] NĚMEC, B.: Die Reizleitung und die reizleitenden Strukturen bei den Pflanzen. 8vo. pp. iv + 154. *pls. 3. figs. 10.* Jena: Gustav Fischer. 1901. Cf. note BOT. GAZ. **31**: 133. 1901.

By use of high magnification the protoplasmic strands in Allium root tips can be shown to be bundles of fibrillae. These fibrillae have a definite sheath and lie embedded in a special plasma. In other plants the fibrillae could not be so well made out, but enough was accomplished to convince the author that, in general, the longitudinal strands are fascicles of smaller fibrils. In longitudinally adjacent cells the strands (and in Allium, at least the fibrillae also) correspond on the opposite side of cross walls, and the author supposes that the fibrillae are in contact, or perhaps continuous, through these walls. Transverse fibrils were found in certain cells, but never in bundles.

The question whether or not these fibrillae have any connection with the transmission of traumatropic and other stimuli is a difficult one to answer. The influence of a number of changes in external conditions was determined, first with regard to the propagation of the traumatropic reaction, and then with regard to the fibrils. It was found that the conditions which cause a degeneration of the fibrillae diminish the rate of propagation or cause this phenomenon to cease altogether. By a sudden change in temperature the fibrils may be caused to degenerate, but later (unless the change is too great) they form again. The same change lessens the rate of, or puts an end to, propagation of the traumatropic response in the longitudinal direction, but after a time the cells regain their power to respond normally. The return of this power to the cells is always accompanied by the regeneration of the fibrillae.

Another line of evidence is furnished by the study of certain roots of Allium which exhibited an apparently spontaneous nutation, uninfluenced by gravity. In these the starch-bearing cells of the root cap were perfectly normal in appearance and behavior, but in almost all of these roots the bundles of fibrillae were disorganized. Still other evidence was obtained from *Vicia faba*. In roots of this plant the fibrillae are found only in the large plerome cells. If the plerome is severed by a knife-thrust the geotropic reaction either occurs not at all, or bending takes place only so far up the root as the wound. Němec concludes that the bundles of fibrils are the path of conduction for traumatropic, geotropic, and other stimuli. The fibrils are strands of protoplasm specialized for conduction.

The two pieces of research here reviewed are accompanied by figures which are certainly convincing with regard to the facts. To us it appears that the conclusions of the second paper are much better supported by experiment than those of the first. The bundles surely bear a close relation to the process of conduction, whether this relation be causal or not. The author compares the fibrils to the nerve fibers of animals, but it seems to us that there is little similarity.—BURTON EDWARD LIVINGSTON.